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Conservation planning for freshwater ecosystems in Mexico

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ABSTRACT

Freshwater ecosystems are key to maintaining biological diversity and for human well-being. Despite their importance, these ecosystems have suffered severe transformations due to anthropogenic activity. Here we present the first priority assessment of freshwater ecosystems in Mexico at the national scale. Because species' compositional and hydrological conditions vary widely across Mexico we divided the territory into seven distinct regions in order to assign different conservation targets for biodiversity surrogates and to consider specific threats according to their impact in each region. The total conservation area network identified is equal to 30% of the country's continental surface, in which more than 94% of the biodiversity surrogates meet their established conservation targets. The regions of the Tropical Pacific and Gulf of Mexico have the largest proportions of priority sites, followed by the Central Highlands, which contains the largest number of irreplaceable sites. Tropical Pacific and the Baja California Peninsula possess the largest proportion of sites with extreme importance for conservation. Nationally, the percentage of priority sites under protection is 15.8%, of which 5.6% are sites of extreme importance, 4.2% are sites of high importance, and 6% are sites of medium importance for conservation. Our study highlights the importance of conducting conservation prioritization assessments at higher spatial resolution using information that is up to date and doing so in a collaborative way to strengthen decision making. This analysis helps to bridge the research–implementation gap in conservation planning to improve the representation of Mexico's freshwater biodiversity in conservation areas.

1. Introduction

Several authors have suggested that the most endangered ecosystems with the largest protection gaps correspond to freshwater environments and their associated taxa (Abellan et al., 2007; Brooks et al., 2004; Nel et al., 2009). Conservation efforts in freshwater ecosystems have been neglected despite their undeniable importance. Occupying only 0.8% of the Earth's surface, freshwater ecosystems provide habitats for almost 6% of all described species and are essential to sustain human existence (Dudgeon et al., 2006; Revenga et al., 2005). Although freshwater ecosystems are among the richest and most endangered ecosystems, almost all protected areas—the cornerstone of biodiversity conservation efforts—have been designed for terrestrial ecosystems (Herbert et al., 2010; Moilanen et al., 2008). Further, few broad scale conservation planning exercises have targeted freshwater systems, largely because we lack comprehensive and synthesized data on the distribution of freshwater biota and because of their complex nature (Abell et al., 2008).

Because of their importance for human well-being and their unique species compositions, ecological dynamics, and functioning, freshwater ecosystems should be assessed separately from terrestrial and marine systems (Herbert et al., 2010). Moreover, these ecosystems are considered to be in crisis due to the fact that they receive high external pressure (*e.g.*, river flood control, irrigation and drinking water, hydroelectric power) in order to maintain the ever-increasing demands of the human population, especially in semi-arid regions (Dudgeon et al., 2006; Jenkins, 2003). In Mexico, the pressure for hydric resources is strong, thus putting the future of freshwater ecosystems in jeopardy. It has been estimated that in the year 2000, 45% of the country was under high pressure for hydric resources, and 30% was under very high pressure; future projections for 2025 estimate that 55% of the territory will be under very high pressure for these resources. On the other hand, 73% of the water bodies show some degree of pollution because 80% of the urban waste water discharges and 85% of the industrial water discharges are put directly into freshwater ecosystems without any prior treatment (Balvanera et al., 2009). The construction of more than 4000 dams and other hydraulic infrastructure in Mexico has affected the dynamics of these ecosystems and their capacity to dilute and degrade increasing charges of pollutants, negatively impacting its

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biodiversity and that of the surrounding ecosystems (Balvanera et al., 2009; Manson et al., 2009).

As a signatory to The Convention on Biological Diversity (CBD), Mexico committed to implement the Program of Work on Protected Areas (PWPA), which aims to support the establishment and maintenance of comprehensive, effectively managed, and ecologically representative national and regional systems of protected areas for both land and sea. As a first step toward achieving this goal, the National Commission for the Knowledge and Use of Biodiversity (CONABIO) and the National Commission of Natural Protected Areas (CONANP) coordinated national conservation gap analyses using the most complete and updated biodiversity information available for the country.

Previous attempts to identify hydrological priority regions for conservation at a national level (*e.g.*, hydrological priority regions, HPRs) were based on expert panel approaches (Arriaga Cabrera et al., 2000) largely because quantitative approaches were limited due to a lack of data and computing capacities. Because of the work done by CONABIO in the last fifteen years to develop the National System of Biodiversity Information (SNIB), internationally recognized for its unparalleled biodiversity database (Edwards, 2004), there is considerably more spatial data available in order to conduct robust systematic conservation planning (SCP) for freshwater ecosystems. SCP is considered the most effective approach for prioritizing areas for conservation needs, as it offers a structured, efficient, transparent, and scientifically defensible framework to select priority sites (hereafter, conservation area network, CAN; Groves et al., 2002; Sarkar, 2004). The process should take into account the representativeness of species, communities and ecosystems and the socio-economic viability of the area identified for conservation, thus the goal is to represent all biodiversity surrogates (up to their targets) in a spatially efficient configuration, while considering social and economic limitations for conservation (Sarkar, 2004; Linke et al., 2011). SCP relies on optimization algorithms in order to process and apply rules for the efficient selection of conservation areas ensuring that certain criteria (*e.g.*, socioeconomic) are met (Groves et al., 2002; Margules and Pressey, 2000; Sarkar et al., 2006). In addition, multitaxa approaches with broader sets of conservation targets have improved upon single-taxon approaches to demonstrate critical efficiency for identifying areas likely to promote the persistence of most species (Kremen et al., 2008).

Despite the importance of freshwater ecosystems and the acknowledged need to count with a conservation strategy in a mega-diverse country like Mexico, which faces severe impacts and threats to biodiversity (Lara-Lara et al., 2008), no systematic priority setting exercise for these types of ecosystems in Mexico has been carried out until now. In this study we present the first national prioritization and gap analysis for freshwater biodiversity conservation in Mexico following SCP principles. Prioritizations were conducted separately for seven regions across Mexico in order to consider limnological, hydrological and physiographic differences, as well as the impacts of threats on biodiversity (Fig. 1). This work presents an analysis in a megadiverse country in which a large amount of spatial biodiversity and socioeconomic data were compiled and analyzed over a two-year process with the guidance of experts, to set up and validate the conservation planning exercise.

2. Material and methods

2.1. Biodiversity surrogates and conservation targets

Information for a total of 3536 biodiversity surrogates was compiled from the SNIB and contributed databases from several academic institutions provided by national experts. To set up conservation targets, recommendations from 52 experts who work on freshwater and inland aquatic ecosystems from research institutions, conservation NGOs, and the governmental sector (see Acknowledgements), were reviewed in two workshops guided by the authors of this manuscript and through an Internet portal designed explicitly for this exchange. Following Groves et al. (2002) we used biodiversity surrogates that correspond to different levels of biological organization and spatial scales, from local to regional. The local level of organization was characterized by species distributions (occurrence points: fish, amphibians, and crustaceans;

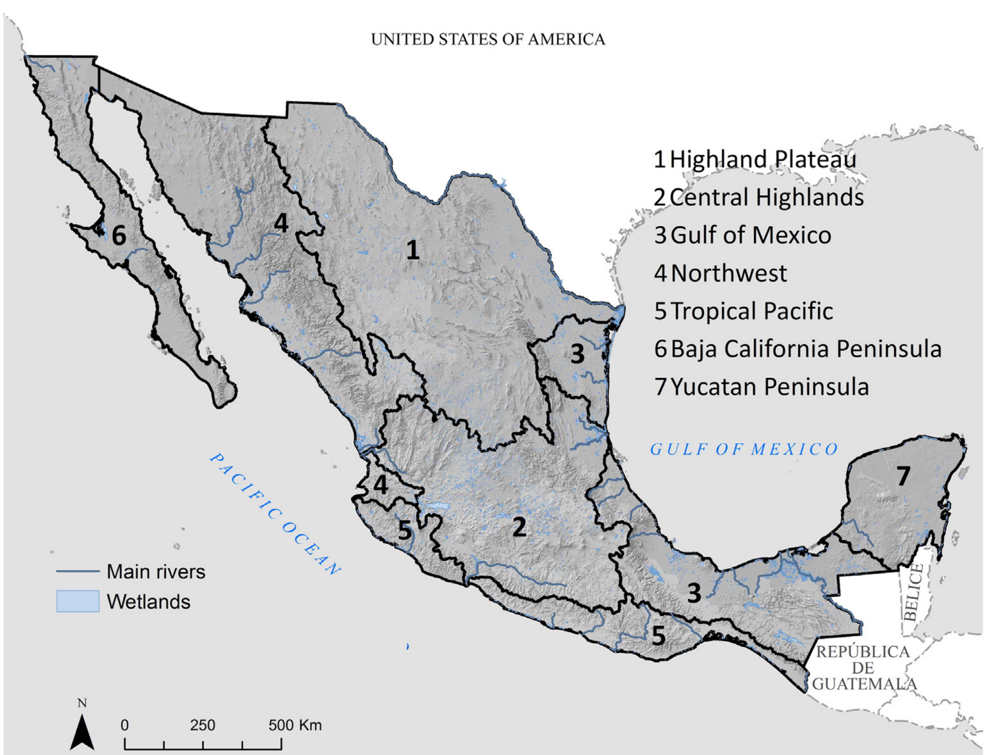

Fig. 1. Seven hydrological regions where prioritization analysis were conducted. These regions depict different hydrological and climate conditions, as well as freshwater ecosystems and human dynamics.